

CHAPTER 3

GUIDELINES FOR CREATING A HIGH-SKILL TRANSIT MAINTENANCE ORGANIZATION

INTRODUCTION

The maintenance departments of public transit agencies in North America face a growing skills problem. The proliferation of new technologies in their vehicles and new regulatory requirements (e.g., reduced emissions and wheelchair access) are generating new skill demands that much of their existing workforce is ill-prepared to meet. The specialized nature of these skill requirements makes it difficult to hire individuals with all of the necessary competencies from the external labor market. Thus, the onus is on transit agencies themselves to find ways of closing the skills gap.

The guidelines presented here are designed to help key stakeholders in transit maintenance (e.g., mechanics, maintenance managers, supervisors, unions, internal trainers, and external education providers) to work together to create high-skill maintenance organizations. The guidelines reflect the results of a national survey of North American transit agencies, six detailed case studies of innovative approaches to developing and using the skills of the maintenance workforce, and a review of best practices in improving skill levels in other public and private sector organizations.

Two Key Themes

Before discussing specific steps that maintenance departments can take to improve the capabilities of their organization and workers, it is useful to begin with two of the main, more general lessons that emerged from the research for agencies introducing reforms to skill development and work organization: (1) create a new labor-management partnership for organizational restructuring and (2) build a learning organization.

A New Labor-Management Partnership

If skill investment is to have an adequate payoff, the work process and reward structure within many maintenance departments must be restructured. The tradition of narrow job titles, a seniority-based system of job assignment, and control of overtime, along with often adversarial relations between management and unions, needs to shift toward

broader, more flexible job definitions and mechanisms to encourage employee involvement in improving maintenance performance. Otherwise, agencies may find that they are wasting their training dollars—as workers quickly forget skills that are not put to use—and that training is counterproductive, as employees become frustrated by raised expectations that are not translated into better jobs or financial rewards.

For unions to give up a seniority-based system, which has been so central to their identity, management must offer an attractive alternative: a competence-based career ladder. This would reward individuals as they acquire and demonstrate additional skills and could create additional opportunities for skill development through systematic job rotation. Agencies would not only benefit from having a more capable workforce able to move more easily between tasks, but could build these skills more cost effectively, as many highly motivated workers are willing to invest in their own skill development if they can see the potential rewards.

Similarly, if managers wish to tap the expertise of their workers in improving maintenance efficiency, then they need, at a minimum, to guarantee that these suggestions will not result in layoffs, and, ideally, should share potential cost savings with the workforce. Where workers have equivalent certified skills, seniority could still be given preference. This combination of continuous improvement through employee involvement and skill-based rewards helps the success of Japanese manufacturing firms. This model is being used by leading U.S. companies.

A Learning Organization

Transit maintenance departments, even those that have made a heavy commitment to raising the capabilities of the workforce, appear to be trapped in traditional ways of thinking about skill development. They tend to rely on two extreme forms of delivery—occasional long sessions of classroom training, delivered by in-house or outside experts (e.g., vendors or college staff), along with informal, OTJ training by coworkers and supervisors. Although each of these is an essential part of an overall strategy for improving workforce skills and should continue, they both suffer from major drawbacks. It is often difficult to find the time to

release workers for classroom training, and mechanics—like most individuals—tend to learn best by doing, not listening. In contrast, relying on informal, OTJ coaching may not include all workers or may convey the wrong set of skills.

What is needed is a broader approach to skill development—the creation of a *learning organization*.¹ A learning organization enables individuals, groups, and the agency as a whole to work together to continually improve performance. It goes beyond formal and informal individual skill training to creating mechanisms so that the agency itself can learn. Too frequently, one hears accounts of one mechanic spending a day fruitlessly trying to diagnose a problem, only to learn that a coworker on a different shift had diagnosed the same fault but not shared the information. With the rapid development of various forms of electronic communication, such as the Internet, the potential for sharing problems and solutions could be extended not only across shifts, but to all transit agencies with similar fleets.

A learning organization also means going beyond classroom training to create continuous learning opportunities for mechanics in the design of their jobs and during slack periods in the weekly work routine. The advantages of this approach are that individuals can develop skills as needed and when the costs of releasing the worker are minimized.

A Two-Tiered Approach

The guidelines that follow can be implemented in two ways. The more conservative approach takes the traditional organization of work as relatively unchanged and seeks to adopt specific skill development strategies that can better equip workers to deal with the challenges of new technologies. This approach can address some of the most pressing maintenance skill deficiencies and may yield real performance gains.

The more radical strategy links a skill-based career ladder with the introduction of self-managed teams of mechanics who have full responsibility for a set of vehicles. This higher-risk approach can yield major improvements in performance, as one small agency—Ann Arbor Transit—has shown over the past decade. Larger agencies, which are likely to find it more difficult to bring about such major organizational change, could experiment with autonomous work teams in a single facility to test the effects on performance.

DEVELOP A SKILL STRATEGY

The first step in creating a high-skill maintenance organization is developing a clear rationale and strategy for change. This strategy should start with the transit agency's overall

mission and explain how this mission can be better achieved by raising the skills of the maintenance workforce. The next step is to set specific goals for skill development and an implementation plan for how these goals will be attained. Finally, the plan should indicate how progress against the goals will be measured. Key elements in this strategic planning process are as follows:

- **Communicate the need for change.** Often the hardest part of bringing about organizational change, particularly in a non-profit agency, is convincing employees of the need for reform. Where there is an external catalyst, such as the threat of contracting out work or cuts in funding, then the case for change may be clear. In the absence of an external threat, however, able leadership can still bring about radical change. The key is to start the process by sharing the rationale for reform and the vision for the future with employees.
- **Involve key actors from the outset.** To build long-term support for the changes and investments required to build a high-skill maintenance organization, it is vital to involve all of the main stakeholders—experienced mechanics, supervisors, and unions. Although this may slow the start-up phase, agencies that did not actively seek the input of stakeholders into program design and delivery found that they later faced resistance from individuals who were threatened by the innovation. This is particularly important for apprenticeships, because the trainees will spend most of their time in the garages with these coworkers.
Similarly, it is essential to seek and maintain the support of upper management if the innovation is to be sustained. They may not be as involved in the implementation process, but top managers who are convinced that the investment in a high-skill maintenance organization is related to the accomplishment of the agency's overall mission will be more likely to protect this investment when budget pressures arise.
- **Redefine the supervisors' role.** Supervisors are essential in any effort to improve the skills of the maintenance workforce and to use those skills more effectively. In many cases, however, they are the single greatest obstacle to change. Typically, they have worked their way up through the ranks and learned how to supervise in a traditional, top-down fashion. They may view efforts to improve mechanics' technical skills and to empower workers as direct threats to their authority. If reforms are to succeed, agencies must start by redefining the supervisors' role—from traditional control to coaching and facilitating—and providing them with the training they need to operate effectively in a new environment. They need up-to-date technical skills, openness to sharing decision-making, good communication and problem-solving skills, the ability to train others, and a good understanding of information systems. Maintenance

¹ For a fuller discussion of the elements of a learning organization, see S. Mohrman and M. Mohrman, in J. Galbraith and E. Lawler (eds.), *Organizing for the Future*, San Francisco, CA: Jossey Bass Publishers, 1993.

managers must then hold supervisors accountable for the desired management behaviors through careful ongoing assessment.

- **Avoid reinventing the wheel—network.** Creating a comprehensive training program from scratch is time-consuming and expensive. The agencies studied all sought curricula from outside sources—local colleges, other agencies, vendors, or private training providers—wherever possible. Given that the basic content of these training programs is similar and that many of the agencies with established programs are willing to share their materials, it makes sense for agencies to start by gathering existing materials which can be tailored to their own needs. The process of learning from other agencies can also help maintenance departments decide what elements to include in their program and reveal likely implementation difficulties. As personal computers and electronic mail become established in maintenance departments, it will be possible to share course materials and even deliver training on line.
- **Be proactive, rather than reactive.** It is not enough to focus on current skill demands; maintenance managers need to plan for future skill requirements. Too often, training is only reactive—a class is put together to try to solve a recurring problem. At some of the more innovative agencies, however, managers anticipate potential skill problems and use training to make sure that they do not occur. SunLine Transit, for example, was able to switch its entire fleet from conventional gas to CNG in a single day, because all of its maintenance employees had been trained intensively beforehand on how to work with the new technology.
- **Create time for training.** Part of acting proactively is allowing people the time required to develop their skills. Too many maintenance departments spend much of their time “fighting fires” on the second and third shifts in order to make pullout, instead of focusing effort on preventive maintenance to try to avoid these breakdowns in the first place. Shifting toward more planned maintenance will improve vehicle reliability and make it easier to schedule time off the job for people to undertake training and to enable trainees or coworkers to observe different maintenance tasks.
- **Think systemically.** Too often, a single training program or quality initiative is viewed as a “silver bullet” that can solve any maintenance problem. Agencies need to adopt a *systems approach* if they are to succeed in creating a highly skilled maintenance organization. This means recognizing the relationship between different forms of training (e.g., do not offer a large-scale apprenticeship for new mechanics without recognizing the need to upgrade the skills of existing mechanics and supervisors) and making the connection between skill development and work organization (e.g., there is no point in upgrading the skills of the workforce if they are not then

given the opportunity to use these skills on the job, or, in attempting a major restructuring of the workplace without training people for their new roles). These may seem straightforward lessons, but they were ones that some agencies missed when first introducing their innovations.

Agencies need to adopt a systems perspective in setting their skill strategy. The sections that follow offer a step-by-step systems approach to developing a high-skill maintenance organization. The systems approach starts with mechanisms for understanding the new *skill demands* facing agencies and the existing *supply of skills*. It is by comparing these two that maintenance departments can identify key skill shortages on which to concentrate their development efforts. The *skills-creation system* encompasses the various mechanisms, from in-house training to outside courses to systematic job rotation, that maintenance departments can use to raise the competencies of their workforce and to fill skill gaps. Equally important are innovative approaches to *skills utilization*, including work redesign and management practices that can be used to meet the new demands on maintenance organizations. Ultimately, the success of any skill innovation will depend on its effect on maintenance performance. *Performance measurement* is critical for determining skill needs and for evaluating the benefits of any strategy.

SKILL DEMANDS

One clear finding from the research is that the skill demands on transit maintenance workers are changing rapidly and the pace of change is likely to accelerate in the coming decade with the introduction of new technologies. This is reflected in the shift in job titles from “mechanic” to “technician” at many agencies. Although mechanical aptitude remains important, individuals require an additional set of skills: greater proficiency in math and reading, a clear understanding of how to use automatic diagnostic equipment, and, increased knowledge of electronics and computers. Similarly, supervisors will need to keep abreast of the latest technology developments and may require new capabilities in order to use new information systems and effectively introduce new management practices.

The precise mix of skill demands, however, will vary by agency. Each maintenance department must analyze changing skill demands to tailor their training.

- **Analyze the work process.** The first step in any effort to identify and address skill problems is to review the work process and what the most pressing skill needs actually are for the maintenance workforce. This can be done formally, by hiring outside experts familiar with job analysis techniques. More typically and less expensively, it can be done informally by observing and interviewing mechanics and supervisors or conducting small

group discussions with them to understand how skill demands are changing.

The analysis should focus on tasks rather than jobs, because reviewing the maintenance workload may suggest ways of reorganizing work to improve efficiency.

- **Minimize maintenance problems through “best value” acquisition.** At first glance, the procurement process appears only distantly related to maintenance skill demands. However, the best way to be proactive about minimizing future maintenance problems, and hence future skill needs, is to purchase a reliable, easy-to-maintain fleet of vehicles. The industry norm, however, remains low-bid procurements, where the maintenance department often has little or no input into the technology being purchased. One common case is the introduction of electronic fareboxes. Both the purchase and repair of the new equipment are, at least initially, often outside the maintenance department’s control, and yet these fareboxes are the number one source of roadcalls.

It is possible, as Pierce Transit has shown, to reduce maintenance problems through best-value contracting, where the agency takes into account the total life cycle cost, rather than just the initial purchase price. The FTA and other federal agencies support the use of best-value contracting. This process can be facilitated by requiring data on past performance and reliability from each bidder.

SKILL SUPPLY

Alongside the analysis of new skill demands, maintenance departments need to undertake a review of their existing supply of skills—or a *skills audit*—as a way of setting their priorities for training investments. Like the analysis of changing work tasks, this skills audit can be done formally, with outside experts; in some cases, the outside provider, perhaps the contract training arm of a community college, will perform the skills audit for free, or at a reduced rate, as a means of identifying skill gaps for which it can offer courses. More typically, however, skill reviews occur informally, as maintenance managers and supervisors decide to whom to assign which set of tasks based on their skills and what skills are in short supply.

Below are some suggestions for conducting a more systematic internal skills audit. The information on individual skills can be gathered through a combination of short surveys, interviews, tests, and workplace observation.

- **Review general education as well as technical skills.** One problem with the informal skill review process is that it may fail to reveal the underlying skill problem. For example, a mechanic repeatedly does a new tune-up procedure incorrectly, not because he or she has problems with tune-ups, but because he or she lacks the math skills necessary to interpret voltmeter readings or lacks the reading level required to understand the instructions in

the manual. Thus, a skills audit should focus not just on individuals’ technical proficiency, but also on their educational qualifications and their reading and math skills.

- **Include supervisors and cleaners.** Include all of the maintenance workforce, not just the mechanics, in a skills audit. This means supervisors—whose pivotal role has already been stressed—and cleaners and service riders. The latter are often the first maintenance employees to encounter a problem and can play an important diagnostic role in communicating with bus operators. Cleaners may be a source of new mechanics; however, several agencies have experienced problems training internal candidates to cope with the new technological demands of maintenance because they had failed to screen these workers for basic skills when they were first hired.
- **Certify existing skills.** Just as the skills audit may expose unknown skill deficiencies, it may also reveal individuals with capabilities not currently used by the organization. This is particularly common in agencies where the only hiring route is for semi-skilled jobs, but the salary on offer is high enough to attract skilled mechanics. To motivate and retain these employees, agencies should seek to certify the skills and find ways to put the skills into practice.
- **Create individual skill development plans.** Too often, the only time managers meet with workers regarding skill issues is in a disciplinary setting, where an individual has been cited for repeated work problems. This pattern of negative, confrontational meetings regarding skills can be broken by institutionalizing the skills audit process. After conducting a review of the whole maintenance workforce’s skills, each individual can be given a skill development plan that identifies strengths and weaknesses and targets specific areas to add or upgrade skills. This plan should highlight the shared responsibility between the worker and employer for skill development. Progress toward these skill targets can be measured as part of an annual performance appraisal.

SKILL-CREATION SYSTEM

By combining the analysis of new skill demands with the audit of existing workers’ skills, agencies should have the information required to identify skill shortages for initial training efforts. Research team personnel studied a range of innovative strategies that agencies are using to close skill gaps, including apprenticeships, systematic in-house training, and partnering with external education providers. In this section, research team personnel synthesize the lessons from these cases, first discussing general lessons on what to do and what to avoid in a skills-creation strategy and then providing more detail on four key elements of an effective skills-creation system: (1) hire well-qualified workers, (2) provide high-quality initial training, (3) encourage continuous skill development, and (4) create a sustainable model for financing

skill development and put together a strategic plan for skill development.

- **Build in flexibility through modularization.** Designers of training courses should, wherever possible, break down courses into small units that can be delivered and certified separately. This can facilitate the development of self-study materials, allow trainees to record their progress as they go, and enable mechanics who have already acquired competence in certain areas to test out of those courses.
- **Partner with outside experts.** Small agencies typically lack the internal resources or expertise to develop a full training program. Even larger agencies are likely to find it more effective to go outside for specialized training (e.g., for air conditioning or wheelchair-lift repair). One of the best and cheapest resources is the local community or technical college, which often can provide general mechanic courses (although automotive is far more common than heavy diesel), as well as customized courses for the needs of particular transit agencies. At Houston METRO, for example, the entire training program is delivered by community college instructors who are assigned full-time to the agency; the agency pays only the course unit fees, which are heavily subsidized by the state. For those agencies that do not have a local college with a strong mechanics program, there are a growing number of national resources to draw on. One possibility is to use other transit properties; CT Transit, for example, is now delivering courses to smaller properties in New England. The NTI is attempting to bring together leading properties to share training resources in a national network.
- **Certify attainment.** To ensure the credibility of the training and recognize the major time investment that individuals have made in their own development, it is important to set clear, high standards for attainment and then certify the skills of the individuals who meet these standards. At a minimum, this could be an internal certificate of achievement, although most of the agencies examined went further, gaining external recognition of the training program from state or national departments of labor, local colleges, and/or equipment vendors.

If individuals must demonstrate their proficiency, through a combination of written and hands-on tests, and the qualification they obtain is linked to job openings and pay grades, there are likely to be protests from those who fail the exams. Houston METRO has dealt with this issue by developing their exams in conjunction with an independent, awarding body that then grades all of the tests.

- **Involve instructors in maintenance work.** One of the dangers with full-time trainers or training departments is that they can become too removed from the day-to-day demands of the workplace and lose the respect of front-line workers. This can be a particular problem if the off-

the-job instruction is occurring at a separate college or training center. Some ways to avoid this difficulty include involving expert mechanics in the design and delivery of courses and having trainers regularly spend time working in the shop. A fine example of how this kind of involvement can strengthen an educational partnership occurred at SunLine Transit, where the head of the College of the Desert's alternative fuels program would periodically spend a shift working with the agency's mechanics to stay abreast of the latest technologies.

- **Create a mechanic mentor position.** The quality and consistency of OTJ learning and the linkages between on- and off-the-job training could be improved by creating a new position of Mechanic Mentor. Individuals would continue to work primarily as expert mechanics, but would spend part of their time as (1) mentor to new hires and trainees, (2) liaison with the training department, (3) disseminator of new material from vendors to coworkers, and (4) agent for sharing information among shifts (and with other agencies) on repeat problems and best solutions.

The Mentor Mechanic post would have the additional advantage of creating a career track for the most highly skilled mechanics. Individuals could qualify for the new position and accompanying wage premium by (1) obtaining basic mechanic qualification, (2) demonstrating excellence in mechanic skills, and (3) receiving additional training or certification on how to coach and train others.

- **Use training aids.** The best way to teach maintenance is through demonstration of how the key components actually work. The advantage of simulators is that individuals learn by making mistakes, which can prove costly with real equipment. Most of the agencies studied were using simulators, such as brake boards, wheelchair lifts, and miniature models of train doors, as instructional aids. A few, however, have gone the extra step and built simulators themselves, rather than purchasing them from the outside. Where this was used, it saved money, increased the involvement and pride of workers in their own learning, and helped teach the desired skills in the process.

As new training technologies—such as computer-based training, interactive video, and CD-ROMs—become available for mass transit, agencies should use them to support their other skill development efforts.² Already, some educational software is available for standard courses in health and safety and EEO training. Programs for automotive maintenance could be adapted to teaching electronics and other key vehicle systems.

There are four sequential steps in building a skills-creation system: hiring, initial training, continuous skill development, and paying for training.

² Research in other sectors has shown that such technologies work best if they supplement rather than replace other forms of learning.

1. Hiring

- **Specify general skill requirements for new hires.** Transit agencies can generally afford to be selective in their hiring practices because they pay wages that are highly competitive in their local labor markets. They can reduce their initial training costs by using the above analysis of skill demands to more clearly specify the types of general skills and qualifications they require of applicants. Although they will continue to have to provide training on specific vehicle technologies, they could concentrate their effort on advanced training by ensuring that new workers have basic mechanical, electrical, and electronic competence before joining the agency.
- **Create preferred suppliers/recruitment partners.** One way for agencies to increase the chances of finding applicants with the desired set of basic skills is to form a partnership with an education institution, much like the supplier partnerships that leading companies are now using to improve the quality of key components. The maintenance department can specify the general set of skills it requires to a local school or college and then work closely with them to ensure that students meet these targets (e.g., through a cooperative education program where students spend time learning at the workplace). Several obstacles, however, may hinder such partnerships: lack of consistent demand for new workers to justify the time required to establish a partnership, civil service regulations that prevent special preference in the hiring process, or difficulties that graduates of these programs may have in competing with experienced mechanics available in the local labor market.

2. Initial Training (Apprenticeships)

- **Modernize apprenticeships.** “Apprenticeship” refers to a broad program of initial occupational training that combines off-the-job classroom instruction with a long period (2 to 4.5 years) of OTJ training/supervised work experience. The advantages of apprenticeships, according to the U.S. and Canadian agencies that run them, are that they provide individuals with a general foundation or bumper-to-bumper understanding of the key areas of maintenance while exposing individuals to an agency’s particular fleet characteristics. For many outsiders, however, the term “apprenticeship” has connotations of obsolete craft training, ill-suited to the needs of new maintenance technologies. These criticisms can be overcome by using the steps described above to modernize apprenticeships—modularizing the curriculum and frequently updating course content, focusing on the certification of competencies rather than time served, integrating new training technologies, and so forth.
- **Integrate apprenticeship with other training provisions.** Even at some of the largest agencies, it is difficult

to sustain an apprenticeship as a stand-alone training program. The number of trainee places depends on the current and projected demand for new mechanics. Because labor turnover is generally low, once vacancies have been filled, it is unlikely that sufficient numbers of new apprentices will be needed each year to cover the staff and other costs associated with the program. Thus, it is beneficial if the apprenticeship can be integrated with other training offerings, perhaps involving the same instructors in delivery of ongoing training, to avoid major fluctuations in the funding cycle. This has the added benefit of ensuring that the trainers remain up-to-date with the latest technology in the fleet, knowledge that they can include in the apprenticeship.

3. Continuous Skill Development

- **Offer equal opportunity for learning, not universal provision.** It is important to offer all employees who desire it the opportunity to develop their capabilities; too often, a small group of the more able mechanics and supervisors receives most of the training on offer. Some agencies and their unions, however, have gone too far in the other direction, insisting that every employee attend each course. In some cases, this may make sense (e.g., introduction to a radical new technology or required safety training); but for most technical courses, it simply results in wasted resources, as individuals who are taught a set of skills that they do not then use soon forget them, while the trainers are so tied up with repeating the same course that they do not have the time to develop new ones.
- **Facilitate learning on demand.** As noted at the outset, one of the biggest barriers to expanding classroom training is finding the time to release mechanics and supervisors from their jobs. However, there is often unplanned slack time in individuals’ work schedules when they could be increasing their skills if the opportunity were available and they had an incentive to do so. Some of the mechanisms managers could use to facilitate learning on demand include learning labs located in or near the garage and stocked with self-study packages (paper, video, and/or computer-based), communication networks for sharing problems and solutions with co-workers both within and outside the agency, and the use of mechanic mentors as described above.
- **Provide tuition reimbursement for all employees.** One of the most cost-effective ways for agencies to increase general skills is to pay the tuition costs of workers who enroll in outside courses, because this avoids the wage costs of both trainer and trainee and does not involve any loss of work. The willingness of individuals to undertake these courses on their own time is generally a strong signal of personal motivation. Although agencies may want to place some limits on the types of courses individuals take, it may pay not to be too restric-

tive, because some vital skills for mechanics and supervisors, such as reading, can be improved through a variety of courses.

- **Improve the quality of vendor training.** The manufacturers of bus and rail cars and key components are key providers of skill development within agencies. However, the quality and quantity of the training they provide is rated as very uneven by maintenance managers, and many complained that the manufacturers were now cutting back on their training departments. Agencies can take various steps to improve the value of this resource, including the following:

— **Make training a key discriminator in source selection.** The procurement specification should include a section that asks the vendors to identify what types of training and learning materials (e.g., manuals, videos, and computer software) they will provide, indicating that weighting will be given to this in source selection. The quality of the training can be assessed through references from other recent customers and by letting vendors know that any training they provide will be carefully rated and the ratings will be used to assess future acquisitions.

— **Evaluate vendor training prior to deliver.** It is useful to send the individuals responsible for in-house training to the vendor's course before finalizing agreement on a larger training contract. If the quality of instruction is low, it may be more effective to deliver the training in house.

4. Paying for Training

- **Seek outside support.** One advantage of partnering with external experts is that they may be more familiar with the potential sources of public support for training. Agencies are tapping into a wide array of funding sources, both obvious (federal and state training programs) and obscure (e.g., the gas company and regional air quality commission to help support the conversion and retraining needed to introduce a CNG fleet). Public training programs, however, often come with regulations and accompanying reporting requirements that can conflict with agency objectives; one agency that used Job Training Partnership Act (JTPA) funds to launch its apprenticeship program found that the displaced workers it was obliged to take lacked the necessary foundation skills to benefit fully from the training.
- **Record outputs as well as costs.** Although the costs of apprenticeships (e.g., trainee and trainer wages, course materials, and overheads) are usually transparent, the benefits from this training are often not recorded; however trainees spend most of their time (particularly in the latter stages of the apprenticeship) doing productive work, usually at a wage significantly lower than that of full-time mechanics. Thus, although the gross costs of apprentice-

ships are high, the net costs are much lower; in one large agency, for example, the total cost of the apprenticeship program was almost \$3 million per year, but two-thirds of this was trainee salaries that were treated solely as a cost in the training budget. This type of calculation can be particularly crucial when upper management is seeking to cut costs in response to budget pressures.

- **Treat training as a revenue generator.** One way of elevating the profile of maintenance training within the agency and reducing overhead costs is to market training services to outside parties, such as smaller transit properties that lack training departments or other public vehicle fleets.

CT Transit, for example, is now delivering courses to smaller properties in New England; Orange County (CA) Transit Authority and Dallas have attempted to establish regional training centers. This may be particularly attractive to agencies that have introduced alternative fuel technologies where expertise is scarcer.

SKILL UTILIZATION

- **Link skill development with work tasks.** Any skill, whether newly acquired or of long standing, is useful only when it is put into practice. If a worker is not allowed to use a skill, particularly one on which he or she has expended considerable effort to develop, skills may deteriorate, requiring retraining when the opportunity to use them does arise. As noted at the outset, however, the need to match worker skills with tasks can come into direct conflict with strict seniority-based work rules. Thus, putting skills into practice effectively requires a new compact between management, workers, and the unions.
- **Create skill-based career ladders.** The key to making a new compact work is a shift from seniority- to skill-based career ladders, where individuals' demonstrated capabilities are linked to the jobs they are asked to perform and the rewards they receive. One of the most common complaints across the case study sites was the lack of career advancement paths for mechanics. Even those who pursue further training on their own time often find the only way they can advance is by waiting for a supervisor vacancy. A skill-based career ladder would define the new technical, management, and other skills that jobs require and reward individuals who attain them.
- **Balance specialists and generalists.** Effective skill use also requires a balance between mechanics who specialize in key areas (e.g., engine rebuild and transmissions) and generalists who can move easily from job to job, although they lack some of the in-depth understanding for particular tasks. Job rotation of workers is often seen as a compromise between the two extremes of work organization, where specialists periodically change jobs

and learn new skills. However, if the interval between rotations is too short, much of workers' time in a given position is spent in learning the new skill.

- **Empower the mechanic workforce.** As in most organizations, the individuals with the greatest knowledge about the work process and how to improve it are the frontline employees—in this case, the mechanics. Most agencies do relatively little to tap this potential knowledge in order to improve productivity. When agencies do try to harness this resource (e.g., through a TQM initiative) they often make two mistakes: imposing the change from above, without buy-in from the workers, and/or failing to create an incentive for change, which workers may view as threatening to job security. To gain worker input into improving maintenance performance, managers should (1) try to build the change from the bottom up, giving workers ownership over the process, (2) ensure no one will be laid off as a result of productivity improvements, (3) share any gains from cost savings with the workforce, and (4) publicize any successes.
- **Improve information flow.** Information flow is critical to maintaining new technologies. New technology requires more complex repairs and reference material, such as schematics, wiring diagrams, and information on using new diagnostic equipment. Several agencies have found that, unlike with older mechanical systems, mechanics now need complete sets of technical manuals readily available on the shop floor, in sufficient quantity that several people can refer to them simultaneously. Technology is providing some help in the form of electronic reference material available by easily movable terminals that are rugged enough to be used in repair bays (newer versions of the manuals also support parts ordering from the pages of the manual using touch-sensitive screens).
- **Pursue applied research.** An important aspect of being a learning organization is that the organization and all of its members seek to continually improve operations. In maintenance organizations, however, suggestions on modifying procedures can be technically complex and may have far-reaching effects. Such changes need careful professional review (as in the Mechanical Review Board run by Pierce Transit) and a credible estimate of benefits so that those benefits can be compared to costs.

One method for institutionalizing improvement that leads to solid estimates of the resulting benefits is to have a program of applied research, where tests of new maintenance techniques are conducted on a continuing basis. If the mechanics are actively involved in conducting these tests, the effort gains credibility from their participation as well as stimulates new ideas from the staff based on their experiences with current tests.

Most agencies conduct tests, particularly of new products, but these local tests lack visibility across the industry and are often informal rather than controlled

experiments. Even larger agencies may require outside partnerships to carry out such experimentation. At several of the case study sites, agencies had embarked on just such an ongoing program of applied research, using top mechanics and partners (e.g., equipment vendors, local industry, and universities), thereby resulting in substantial savings.

- **Do not marginalize new technologies.** Introducing new technologies, such as alternative-fuel vehicles, requires a new set of skills, new equipment, and, at least initially, increased uncertainty. To manage these challenges, most agencies phase in major changes in technology by applying them to only a small proportion of their fleet, with plans for increasing the number of vehicles involved as the technology proves itself and the agency gains experience with its quirks. However, in the daily push to meet pullout, a small fleet with special problems can be ignored, with the result that the problems persist and the technology is branded a failure. Furthermore, a few agencies have relied on a few non-union technicians to maintain their new fleet. These all shift new technology to the margins of an agency's operation and stop the introduction of the new technology to the rest of the fleet. To avoid these problems, agencies need to plan for the skill needs of a technology before it arrives, and then introduce it, even if just in one garage, in a way that has the full commitment of the workforce.
- **Experiment with the introduction of self-managed teams.** The literature on private-sector firms is full of cases in which a move toward self-managed teams has increased productivity and cut costs. Although such experiments in transit have been rare, research team personnel came across one dramatic example of worker empowerment through teaming at the Ann Arbor Transit Authority (see the text box on Ann Arbor Transit).

PERFORMANCE MEASUREMENT

In the agencies observed, there is a gulf between skills development programs and the output—increased reliability and greater productivity—they are meant to enhance. The connection is often simply assumed or ignored. Yet this connection must be made. Measuring the relationship, if any, between innovations in skill development and maintenance performance enables managers to

- Justify the investment to top management,
- Build continuous improvement into the training process,
- Identify factors outside of the trainers' control that may be hindering the effective use of skills, and
- Eliminate or redesign those programs that do not show payoffs.

Many better agencies now undertake three steps to assess training effectiveness: (1) ask trainees to rate courses, (2) con-

EXAMPLE: A HIGH-SKILL MAINTENANCE ORGANIZATION—ANN ARBOR TRANSIT

The Ann Arbor Transit Authority (AATA) instituted independent mechanic teams in 1988, eliminating all of its maintenance supervisory structure except for the single maintenance manager. At AATA, all mechanics are split into teams that “own” vehicles. These teams control all aspects of repair on the vehicles, setting preventive maintenance (PM) schedules and the tasks to be done during PM; they negotiate workload among team members and, within certain parameters, set their own schedules. Given certain cost constraints, the teams are measured on their ability to meet pullout and to achieve reliability goals, captured in miles between roadcalls. Between 1988 and 1993, miles between roadcalls increased more than 500 percent; labor output increased as well (though nowhere near as dramatically) with a 15 percent improvement in revenue miles per maintenance manpower equivalent.

AATA’s experience suggests several lessons for making such a radical change work:

- **Secure support of key stakeholders**

AATA’s maintenance manager conducted extended negotiations with the local union’s president (who conferred with the national leadership) before moving into full-scale teaming, discovering their concerns, and adjusting the program to meet them. Before making teams departmentwide, the maintenance manager experimented with a small group (in fact, first beginning with a “team” of one mechanic). This pilot program tested the merits of the new concept and served to advertise its benefits to the skeptical workforce who then asked to be included. At each step, the maintenance department advised higher management of the changes and took steps to alleviate their concerns.

- **Provide training for teamwork and increased technical demands**

To ensure that the two-man teams had access to all the skills necessary to do all repairs on their vehicles, AATA’s maintenance department offered a ten-module course for skill development developed for them by the Universal Training Institute. To improve teamworking skills, the department brought in an outside consultant to provide training on interpersonal and communication skills.

- **Guarantee no layoffs**

AATA had the advantage of being able to focus on reliability improvements rather than on budget constraints and so could promise that performance improvements would not result in layoffs. In addition, AATA has seen efficiency improvements (in terms of output per mechanic) and so has been able to forgo additional hires and accept attrition.

- **Find new roles for supervisors**

The principle that no employee would lose his or her job as a result of the new structure was most relevant for supervisors whose responsibilities were eliminated. Special efforts were made to find productive new roles for supervisors. One became the full-time trainer, another took over component rebuild, a third decided to leave the organization after becoming dissatisfied with his options. Management attention and intervention with the rest of the organization were required to protect the ex-supervisors’ salary levels after their responsibilities had changed.

- **Avoid divisive competition among teams**

Teams will unavoidably have differing workloads. Some have older or more troublesome vehicles than others; some may have more experienced and skilled team members. AATA is careful not to use performance measures to make invidious distinctions between teams or among mechanics. Rather, performance metrics are used to identify problems with the vehicles and to determine the need for further training. In addition, teams spend up to 20 percent of their time working on other teams’ vehicles, bringing additional skills to bear and developing a sense of cooperation and shared goals.

- **Create ongoing challenges**

Successful teaming strategies such as AATA’s create a sense of pride and commitment to a common goal among the workforce. Against this, however, is the danger that arises when goals are met and the enthusiasm and pride of the workforce do not find new outlets. At AATA, morale among the mechanics began to slip when improvements began to plateau. To maintain workforce motivation, the agency began considering new challenges for the workforce, such as mastering whole new vehicle capabilities, such as global positioning technology and other advanced electronics.

duct before-and-after tests to see if skills have improved, and (3) observe whether workers correctly use the skills on the job. Research team personnel suggest adding a fourth step: analyze the effect of training on maintenance performance at the level of the individual, the group and garage, and the agency as a

whole. Although it is often difficult to isolate the effect of improved skills from other factors (e.g., new vehicles, change of management, and improved maintenance equipment/facilities) that affect maintenance performance, it is possible to make significant improvements in current practice.

- **Start by analyzing current performance.** Before embarking on an aggressive effort to improve the skills levels of its workforce, the agency must have a clear understanding of the shortfalls in its current performance. The manager must be able to determine if current performance on the most important metrics is not meeting goals and how skills gaps may be contributing to unsatisfactory performance.

This latter point is especially critical. It may be easy to determine that reliability or cost metrics are trending downward, do not meet some set goal, or do not match some peer group. It is harder to relate that poor performance to problems in skills. Yet to justify a skills-development program, performance metrics must be constructed to make that link. At the other end, agencies must be able to establish that training and/or other workplace reforms have shown benefits, using the same types of performance measures.

Mechanisms that agencies can use to measure the need for and the benefits derived from such workplace changes are as follows:

- **Focus on both general and specific outcomes.** Most agencies measure their performance in terms of general averages or other gross statistics (e.g., average miles between roadcalls). High-performing organizations focus, in addition, on the variability of their performance and, beyond that, to the cause of particular failures. For example, all vehicles that suffer egregious numbers of roadcalls (e.g., that consistently lie more than one standard deviation above the mean roadcall rate or are consistently in the worst quartile of performers) would be isolated for careful examination: Is this vehicle truly prone to frequent roadcalls? Is there anything in the maintenance it receives that might account for its frequent breakdown rate? Should it be placed in a less demanding service role? For repeat breakdowns for the same cause, the maintenance records—who did what, what parts were used, how was the fix tested—would need to be examined.
- **Perform diagnostics on mechanic performance.** The same principle applies to measuring mechanic (or team) performance and applies to capturing the benefits of training. Are particular mechanics having problems with repeat failures? Do some mechanics use more parts than are required for specific jobs or do they frequently use the wrong parts?
A performance measurement system would establish averages and ranges around the averages for mechanics as a whole (e.g., average callback rates by mechanic, the standard deviation, and the distribution of performance) and would then offer the ability to do diagnostics on certain mechanics' performance (e.g., the 25 percent with the highest callback record or the highest parts use for specific types of jobs).
- **Set standard work times where possible.** It is hard to measure performance if there is not first a standard against which to measure it. The transit industry, however, is littered with failed efforts at setting standard work times; the inherent uncertainty of some repairs and worker opposition makes it hard to set uniform standards for completion. But there is a significant percentage of all tasks, preventive maintenance (PM) in particular, that can be relatively easily standardized. Given the problems with past standard-setting efforts, agencies should start slowly, with routine tasks, and make clear that the standards are intended as tools for continuous improvement.
- **Use multiple performance indicators.** Many agencies that try to assess the effect of training use only a single indicator (such as miles between roadcalls). Although this is one of the most important indicators, it is useful to supplement it with various measures that may be affected by training—cost-per-mile, number of workplace accidents, number of repeat breakdowns, staff-hours per repair, absenteeism, employee satisfaction (as measured through internal surveys), customer satisfaction (that of the operators as well as the public), and so forth. The danger of relying on a single indicator is that, in an effort to maximize this factor, the maintenance department could hurt overall performance by rushing repairs that result in repeat breakdowns or reducing miles between roadcalls by replacing parts prematurely.
The information required for developing all of these measures may sound far too time-consuming for many agencies. In reality, however, much of the data is already being collected for Section 15 and internal reporting requirements. The object should be to analyze and present the information in a way that managers and individuals can use to improve performance (see the box below for an illustration).
- **Provide “360 Degree Feedback” to individuals.** Many leading U.S. corporations are now using a process called 360 degree feedback to provide individuals with a more complete picture of their performance.³ This process involves asking supervisors, coworkers, and subordinates to rate the performance of an individual and to identify areas for improvement. These different views are then synthesized and shared with the individual in an annual performance review. The 360 degree feedback process might be particularly useful for supervisors, who as one senior foreman described it, “feel caught in the middle between management and the mechanics.”
- **Use information to reward not punish.** Workers and their unions are likely to resist any effort at performance

³For more information on 360 degree feedback, see Gary Yukl and Richard Lepsinger, “How to Get the Most Out of 360 Degree Feedback,” *Training*, 32 (12), December 1995, 44–45.

measurement if it is perceived, as is now often the case, as a means of disciplining or firing individuals who are not performing well. Managers can help to diffuse this tension by setting clear performance targets (e.g., “we want to be the top performing agency of a given size on a set of measures in the Section 15 data”) and rewarding the workforce if these are achieved. At the individual level, workers who are underperforming should be offered additional training in the problem areas and an opportunity to improve before disciplinary actions are imposed.

IMPROVING DIAGNOSIS OF SKILL PROBLEMS

Information systems can be used to diagnose problems in mechanic performance. For example, Figure 19, created with data obtained from one of the research team’s case studies, is an attempt to identify the causes of callbacks (vehicles that are repaired and released for operations and then return to maintenance within a short time for the same fault).

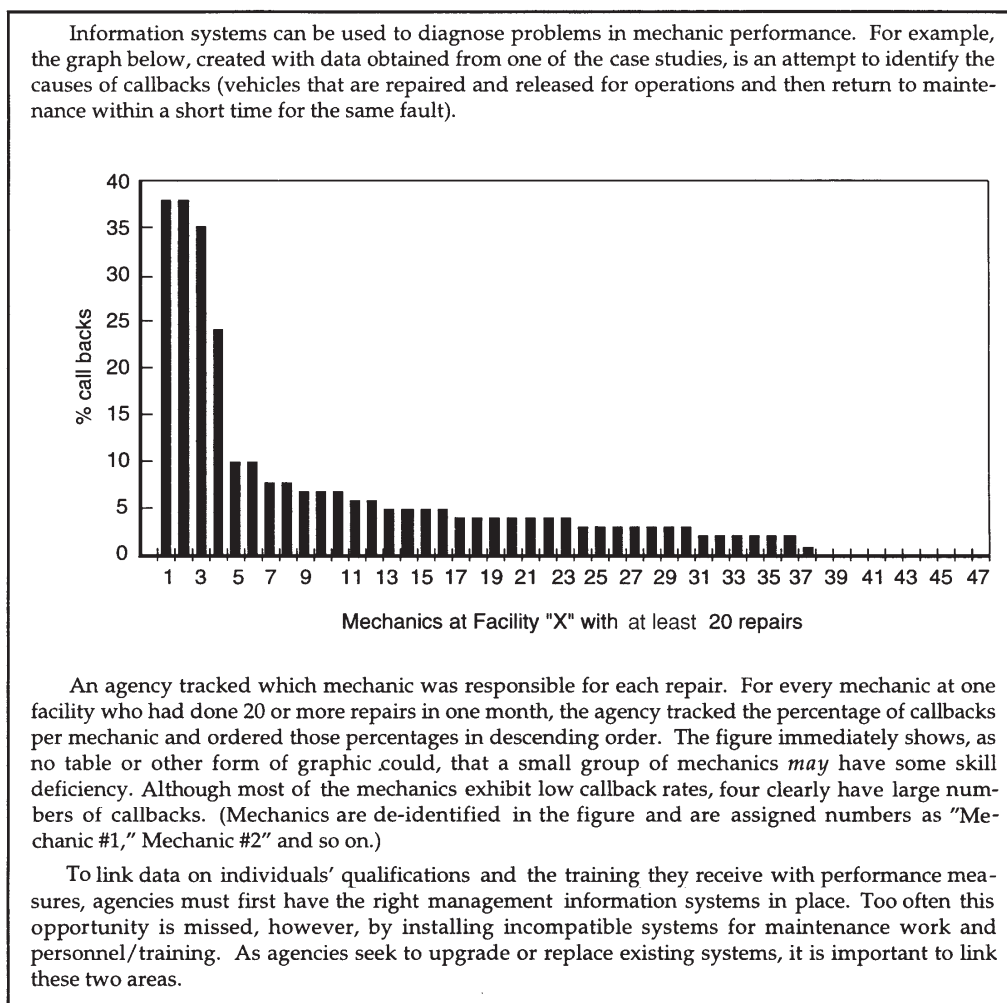


Figure 19. Improving diagnosis of skill problems.

CONCLUSIONS

There is no simple formula to enable transit maintenance departments to create high-skill, high-performance organizations. These guidelines and the research on which they are based are an effort to give practitioners the tools they need to understand the new skill demands facing the transit industry and to develop strategies for meeting these demands tailored to their local circumstances. The major elements of such a strategy are summarized in Figure 20.

Step 1 of this five-step process is forging a new partnership between labor and management that brings the key stakeholders together to define a shared vision for change.

Step 2 is defining the skill challenges facing the agency. This entails an analysis of the new skill demands being generated by technological and regulatory changes and a skills audit of the existing capabilities of maintenance managers and workers. This audit should focus not just on technical skills, but on the general competencies (math and

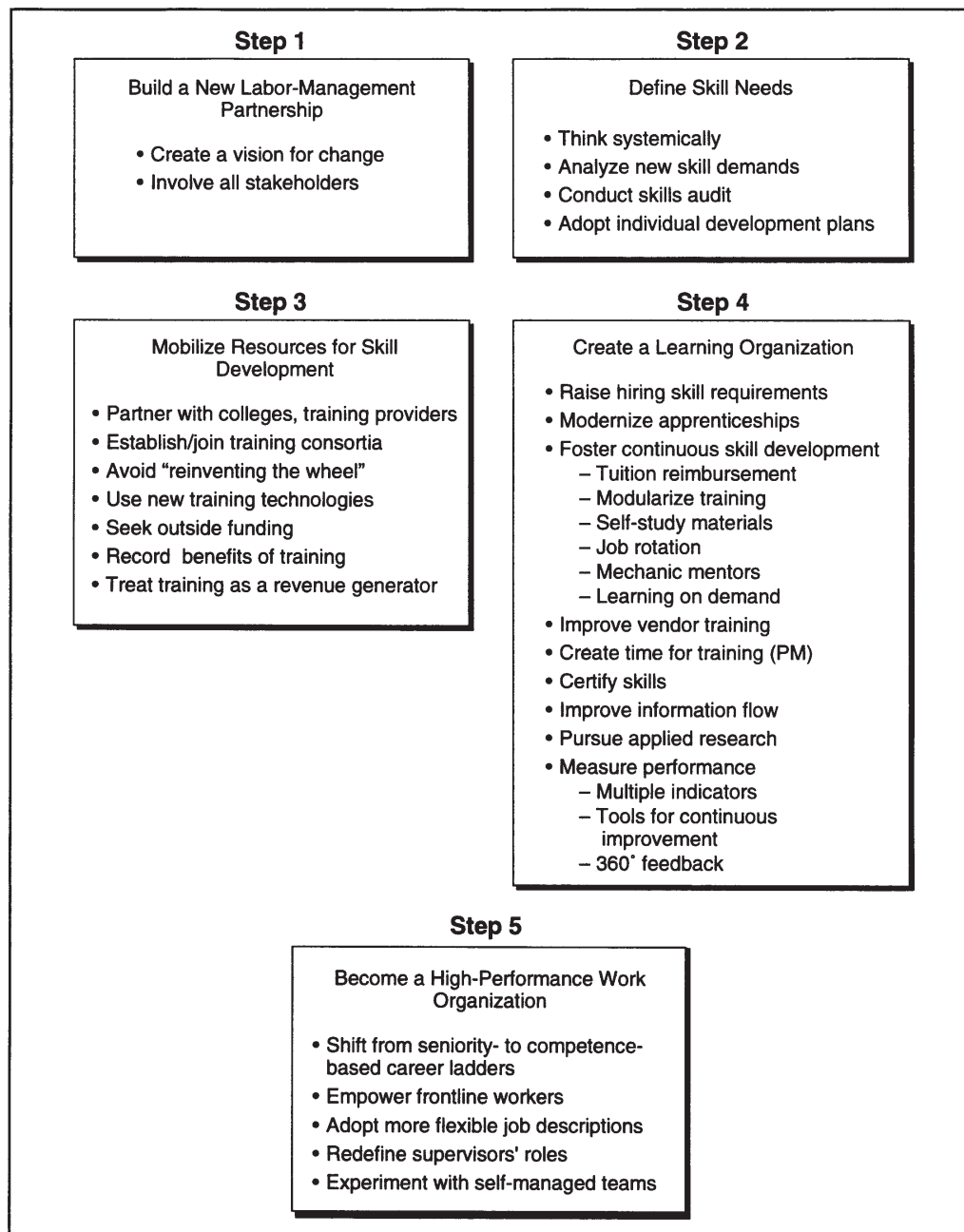


Figure 20. Five-step process.

literacy) and interpersonal skills needed to operate effectively in a high-performance organization.

A vital third step is mobilizing the resources needed for skill development—particularly for the many agencies facing budgetary constraints. Resources include both the money needed to fund training—including grants from federal, state, and local government and private foundations—and educational assets—such as local community colleges and new training technologies—that can reduce the costs of delivering training. By measuring the benefits as well as costs of training and offering courses to outside parties, maintenance departments can make it easier to justify this investment.

The fourth step in this process is to create a *learning organization*. This means giving individuals ongoing oppor-

tunities to improve their skills—through modernized apprenticeships, modular ongoing training, self-study packages, planned job rotation, and support for courses they take on their own time. This also means putting systems in place so that the organization itself can continuously improve, by increasing the flow of information, conducting applied research, measuring performance, and then feeding the data back in a useful form to help managers and workers solve problems.

In the final step, agencies should introduce a high-performance maintenance organization. This entails restructuring the work process and career paths so that individuals are given incentives to acquire skills and the power to use them effectively on the job.
